SOME ASPECTS OF THE LIFE HISTORY AND ECOLOGY OF *RHOPAEA MAGNICORNIS* BLKB. (COL., SCARABAEIDAE)

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(Plate 1)

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Synopsis

Information is given on the morphology, life history and distribution of *Rhopaea magnicornis* Blkb., which damages pastures, sugar cane, arrowroot and pineapples in the coastal regions of northern New South Wales, and is also a pest in Queensland. The regeneration of vegetation in pastures after injury is discussed. The history of damage due to the insect is outlined and natural enemies mentioned.

Introduction

Several species of the genus *Rhopaea* are known to be injurious. *R. vestita* Arr. and *R. subnitida* Arr. are recorded as pests of sugar cane (*Saccharum officinarum* L.) by Arrow (1915) and Veitch (1919, 1922). Smith (1936) stated that several (unspecified) members of the genus were pasture pests in southern Queensland, and Smith (1946a) that *R. magnicornis* was an important pest of peanuts (*Arachis hypogaea* L.) in southern Queensland. Saunders (1957) reported that a species of this genus damaged paspalum (*Paspalum dilatatum* Poir.) on Buderim Mountain in 1911, roots of wheat (*Triticum aestivum* L.) at Pittsworth in July 1915, paspalum pastures in the Kingaroy district, peanuts at Kingaroy and pastures in the Lower Burnett in 1936. He also stated that species belonging to this genus were responsible for damage to pastures in the Bundaberg district at Bingera in 1904 and Isis in 1910.

R. verreauxi Blanch. has been bred from pastures in the Dorrigo district where damage has occurred for upwards of 30 years. Similar damage on the Comboyne Plateau has been caused by a species of scarab, probably of the same genus.

Stages of Rhopaea magnicornis Blkb.

Adult

The beetle is a typical melolonthine of uniform brownish colour (Pl. 1, figs. 1–2). The whole body is lightly punctate and bears numerous very fine hairs. Each sex has ten-segmented antennae and large hind wings. The female is obviously bulkier than the male. The measurements of 50 males and 14 females collected in the field are tabulated below:

	Males	*Females*
Total length, mm.	22·0–25·0	24·0–28·0
Maximum width of elytra, mm.	11·0–12·5	12·5–14·5
Maximum width of prothorax, mm.	8·5–10·0	9·5–11·5

In the male the last eight segments of the antennae are expanded into large lamellae which, when folded together, present a somewhat rectangular appearance. The antennae of the female are much smaller, containing six lamellae which form a rounded club when folded (Pl. 1, figs. 1–2).

The pygidium of the female is noticeably wider than that of the male, and has a distinct groove down the mid-dorsal line, on either side of which is a definite but slight ridge. The narrower pygidium of the male has at the most a very faint groove down the mid-dorsal line and no ridges.

Egg

The egg is smooth, white and oval in longitudinal section. Under 16 × magnification a honeycomb pattern may be seen. Measurements made at different stages of development were as follows:

EGG SIZE

Stage at which measured	*Nos. of eggs examined*	*length mm.*	*width mm.*
Eggs dissected from ♀ beetle	9	4·6–5·0	3·9–4·2
Eggs 1–2 days after deposition	21	2·9–3·8	2·4–2·8
Eggs immediately prior to hatching ..	3	4·5–4·6	3·5–3·6

Brimblecombe (1942, p. 4) gave measurements of 2·75 × 2·0 mm., which increased: "until just before hatching the dimensions have practically doubled."

Larva

The larva is a typical curl grub and remains in a permanently curved posture, unable to straighten itself. Consequently all length measurements were made with the ventral surface held against a flat surface.

The first instar has disproportionately long legs and a relatively large head compared with these structures in the next two instars. The raster is not conspicuous.

Second instar larvae are noticeably larger than those of the first instar.

The third instar larva (Pl. 1, fig. 3) has a yellowish head capsule and light yellowish, bristly legs. The number of pali in the palidium varies from 16 to 26. (Saunders (1957) found about 16 setae, i.e. pali, on each side).

Sizes of the three instars are indicated in the following tabulation.

LARVAL SIZE

Instar	*Number of Larvae*	*Head Capsule in mm.*	*Body Length in mm.*
1	12	3·0– 3·2	10–20
2	80	4·5– 5·7	33–44
3	373	6·2–10·2	32–62

In twenty larvae changing from second to third instar Dyar's constant ranged from 1·20 to 1·55 (mean 1·37).

There is a considerable overlap in the sizes of male and female third instar larvae as measured by width of head capsule and by total length. Among 134 larvae bred to adults smaller individuals (6·6–7·2 mm. head capsule width; 39–45 mm. total length) were exclusively males, and very large larvae (8·8–10·2 mm. head capsule width; 53–62 mm. total length) all females, but there was a large percentage of both sexes of intermediate size.

Prepupa

The prepupa is not a distinct morphological stage and varies in appearance in accordance with the time that has elapsed since the discharge of the body fluid. (Pl. 1, fig. 4.)

Pupa

The pupa is a typical scarab *pupa libera* and the sexes are readily distinguishable. In the male the antennae are large and approximately triangular in shape; on the abdomen posterior to segment 9 a trilobed ventral swelling consists of the lateral anlagen of the parameres and the central

anlage of the penis. In the female the antennae are much smaller, curved and cylindrical; the abdomen lacks ventral protuberances, but a depression indicating the gonopore occurs between segments 8 and 9. In each sex the abdomen ends in a pair of fine-pointed curved spines. (Pl. 1, fig. 5.)

Five specimens of each sex were measured:

	Males	*Females*
Length, mm.	30·0–36·0	32·0–34·5
Maximum width, mm.	13·0–14·5	14·0–16·0

Life Cycle and Behaviour

Rearing Technique

Larvae collected in the field were placed in closely-packed soil in 1 oz. (tobacco) tins, a maize grain being placed in each tin as food. The soil was taken from the area where the larvae were found; it was kept at about the same moisture content as in the field and changed approximately monthly.

Pairs of adults were placed in one-quart glass jars, each containing a few inches of soil; after deposition the eggs could be seen through the bottom of the jar. Four eggs were transferred to a tin, one in each corner. After hatching, one larva was allowed to remain and the rest transferred to individual tins. All insects were examined twice daily.

Egg Deposition and Hatching

As adult beetles did not feed, reared pairs were placed together in jars of soil. Two females laid 41 and 28 eggs respectively; virgin females laid infertile eggs. Apparently all eggs were laid between the evening and morning inspections.

Each freshly-deposited egg was loosely enclosed in a small spherical pellet of soil with a hollow in the centre. The egg, at first oval, swelled gradually and eventually filled the whole cavity, by which time it became broadly oval in longitudinal section.

The average incubation period of eggs at room temperature in Lismore was 20·8 days for those laid in early December (temperature range 62–85° F.) and 22·7 for those laid in mid-February (temperature range 64–81° F.).

Eggs were found in the field at Tregeagle and Eltham in December and January from 4 to 9 in. below the surface; no eggs were found at any greater depth.

Larva

A newly-hatched first instar larva was uniform white, except for the mandibles which were darker, especially at the tips, which were black. After the larva hatched, the egg shell sometimes adhered to the larval head capsule. The larva sometimes ate the egg shell. A few hours after hatching the mature colour was attained in the sclerotized areas of the body, while one or two days later soil particles appeared in the alimentary canal. As first instar larvae formed temporary cells in the soil in which they moulted, the exact date of the change could not be ascertained. Twelve eggs were laid between 2nd and 16th December 1933, by a reared female. The mean period of incubation was 20·5 days and the mean period between hatching and the appearance of the second instar larva was 58·5 days.

Larvae reared from eggs did not survive to the third instar; however, of 20 second instar larvae collected in the field in August 1936 and kept in tins, eight moulted to the third instar before the end of October, a further 11 before the end of November, and one in early December.

Just prior to ecdysis, both second and third instar larvae used their mandibles to consolidate the soil and form a cell in which moulting or pupation occurred. The newly-moulted third instar larva remained within the cell for some days during which it hardened and its colour darkened. It often appeared to have eaten the cast skin since all that remained were the second instar mandibles.

When handled, third instar larvae frequently regurgitated a black liquid somewhat more viscous than water, and some defaecated readily; the mandibles inflicted a sharp "nip". Second instar larvae rarely acted in this way. At times larvae were seen to eat their own faeces. Larvae in close contact in the soil will attack and kill each other.

In the field larvae were found at varying depths, being deeper during drier conditions. Whilst eating grass roots the final instar larvae rested on their backs in the soil in small holes which may then be less than an inch below the soil surface. At other times the larvae were most commonly found at a depth of 4–5 in.; in one case a larva was found at a depth of 12½ in.

Samples of larvae were taken at Tregeagle in 12 successive months commencing in August 1940. Third instar specimens were found on every occasion and all large larvae obtained in November and December were in this instar. Second instar larvae were found from January until October. First instar larvae were found from November to March. As third instar larvae were present in every month of the year at Tregeagle, it was concluded that they spend at least twelve months in this instar. In one case, a third instar larva collected in January 1935 did not pupate until December 1936. No insects were reared from egg to adult in the laboratory, but it is probable that the life cycle occupies two years under normal conditions.

Prepupa

The prepupa was found from early October to December or, rarely, in early January. Examples of the latter did not overwinter, but emerged as late adults. One prepupa was found in the field on 7th September 1937, exceptionally early. As the prepupal stage did not involve a moult it was difficult to say precisely when it did begin. The time of discharge of the fluid from the body was taken as indicating the beginning of this stage. The time taken from liquid discharge until the larval exuviae were cast off varied from 8 to 18 days (mean of 34 cases was 13 days).

Pupa

The pupal period under laboratory conditions lasted from 22 to 38 days (72 samples) according to the time of the year, the period naturally decreasing with the approach of summer. Pupation under field conditions occurred mostly in October and November, for in 95 cases 34 pupations occurred in October, 45 in November, 12 in December and 4 in January.

In the field pupal cells (Pl. 1, fig. 6) were found at a depth of four to ten inches.

Adult

The callow adult had pale orange-brown elytra, reddish-brown head and prothorax, light brown pygidium and appendages with the distal sternite of the same colour. The rest of the body was cream. The beetle rested on its legs with the wings held out open straight behind and bearing on their dorsal surfaces several globules of a colourless liquid. When the fluid dried the wings were folded under the elytra. Normal colouration was attained in

about a week. The meconium was deposited from a week to a fortnight after emergence from the pupa. When tins were opened for inspection beetles were frequently found resting on their backs in cells.

In the field, flights of beetles were most common in November, December and in early January. The first flight both in 1934 and 1935 was on 30th November, in 1936 on 20th November, in 1939 on 14th December, in 1940 on 14th or 15th December, in 1944 on 13th December. Rarely were there any beetles about at the end of January, but in 1942 they were still present in early February.

During December evenings flights of beetles occurred with maximum numbers flying between 7.05 p.m. and 7.25 p.m. The time of flight was very regular and probably depended on light intensity. After an unusually hot day, larger flights of beetles were noted, but no flights were observed in wet weather.

Beetles were not seen to rest on solid objects, such as fences, houses, etc., but landed in grass, especially in large tussocks. No special direction of flight was noted. Males greatly outnumbered females in flights. Only 0·9 per cent of the adults taken at lights in the Tregeagle and Dorroughby districts were females; however, one sample from Tregeagle taken at Christmas 1939 contained 34 per cent females. Of 118 beetles bred from third instar larvae, 71 were males and 47 females. Apparently *Rhopaea* females fly much less readily than do the males; this could account for the large proportion of other species of *Rhopaea* in which the female is undescribed. There are no obvious differences between the hindwings of the two sexes of *R. magnicornis*.

The longevity of the adult in the field was not determined, but records were kept of its survival in the small tins used for rearing. Thirty-five males and thirty-six females lived for a general average of 45 days. The longest-lived female emerged on 9th December 1933 and died on 23rd March 1934, 104 days later.

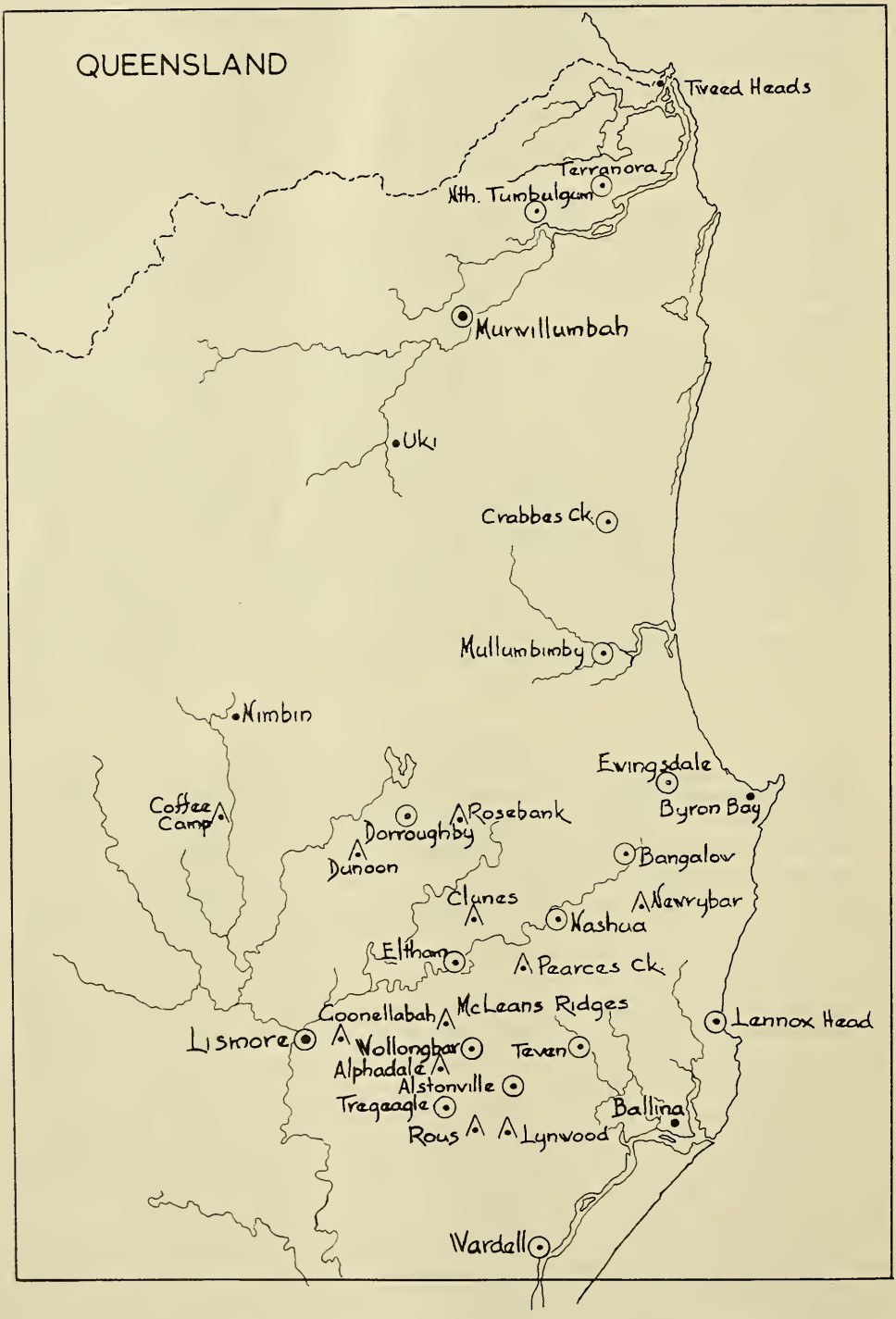
Distribution

Rhopaea magnicornis occurs in south-eastern Queensland and north-eastern New South Wales. However, the Queensland Museum contains a specimen labelled "Cairns J. A. Anderson" and the South Australian Museum one with the data "C. York Pen. C. French 8/11/92"; both are males.

Museum specimens from the following Queensland localities have been examined: Mt. Lamington, Mt. Tambourine, Mermaid Beach, Toowoomba, Yarraman, Numinbah (Nerang River), Caloundra, Stanthorpe and Brisbane. Smith (1946b) records the insect at Yarraman, Benarkin and Googa, and also (Smith, 1947) in the Brisbane Valley. Brimblecombe (personal communication) and Saunders (1957) state that damage in the Kingaroy and Nanango districts (Veitch, 1936) and at Mount Tambourine (McDougall, 1954) were due to this species. The author has seen larvae from Maleny collected in November 1967.

In New South Wales the beetle occurs commonly in the Tweed and Richmond River districts and has been recorded as far south as Wardell in the coastal area; on the Northern Tablelands, specimens are known from Black Swamp (east of Tenterfield), Tenterfield, Glen Innes, Guyra, Wollomombi, Tamworth and Uralla. Chisholm (1929) referring to the Comboyne Plateau, stated that "in early summer (*R. magnicornis*) appears here in loud humming swarms, and attacks flowers and foliage". As the adult of *Rhopaea magnicornis* is not known to feed, this record is highly dubious.

The author reared larvae from Terranora, North Tumbulgum, Ewingsdale, Dorroughby, Nashua, Teven, Lennox Head, Alstonville, and Tregeagle, and



The Richmond-Tweed District.

⊙ Areas from which specimens were identified by the author.

△ Areas from which damage was reported (specimens not examined by the author).

identified larvae from Murwillumbah, Crabbes Creek, Mullumbimby, Bangalow and Wollongbar. Damage to pastures, similar to that caused by *R. magnicornis,* was reported from Alphadale, Chilcotts Grass, Clunes, Coffee Camp, Dunoon, Lynwood, McLeans Ridges, Newrybar, Pearces Creek, Rosebank and Rous. All these areas have reddish soil and are in the area originally occupied by the "Big Scrub", a dense subtropical rain forest of big trees and impenetrable undergrowth. The beetle was bred from a much darker type of soil at Eltham and Lismore.

Nature of Damage and Relationship to Insect Numbers

A. Damage to Pastures

Tregeagle, a dairying district about five miles south-east of Lismore, was selected for observations on pasture damage. It is in undulating red soil country with an average rainfall of about that of Lismore (53 inches). When observations were commenced the pastures were almost all paspalum, with odd patches of buffalo (*Stenotaphrum secundatum* (Walt.) Kuntze) and, rarely, kikuyu (*Pennisetum clandestinum* Hochst. ex Chiov.) grasses. Paspalum was the grass most affected, but buffalo and kikuyu also suffered. Parramata grass (*Sporobolus africanus* (Poir.) Robyns and Tournay) was also destroyed, but its loss was of no significance.

A damaged patch could be recognized by the distinctive light brownish colour which it assumed. Patches were usually oval or more or less circular in shape and varied in size from a few yards to a chain or more across. Paspalum, buffalo and Parramatta grass clumps all exhibited the same symptoms. When a patch was affected, the above-ground portion could be lifted up without difficulty, so as to bring with it the soil and roots. Frequently only $\frac{1}{4}$ to $\frac{3}{4}$ in. of root remained. The base of the sod, where the larvae had eaten, was quite level except for occasional grooves where some larvae had worked closer to the surface than others. Large pieces of damaged turf could be lifted up and rolled up like a mat.

After a time the grass died completely (rarely odd plants remained green), and at this late stage the mat of dead turf would not hold together, but fell apart when any attempt was made to lift it. Eventually the grass separated from the soil and could be raked off. The soil under damaged grass became very loose and spongy, especially in the later stages of infestation. Damaged areas could not be ploughed satisfactorily as the sod crumbled and could not be turned over.

The first instar does little, if any, damage to pastures. Second instar larvae are probably of some significance but there is no doubt that most damage is caused by the third instar larvae which are much larger and more voracious than the earlier instars.

Damage was usually noticed between September and November, although in 1936 and in 1938 it could be seen as early as May.

In May 1939, in order to obtain estimates of the abundance of larvae, a square of side three chains was selected in an undamaged area and divided into nine plots each of one square chain. In seven of these plots, five holes one foot square and eight inches deep were dug at random. The average number of larvae per square foot was 4·3. Of the total of 152 larvae recovered from 35 samples, 37·5 per cent were in the second, and 62·5 per cent in the third instar. The area did not show any damage in the following summer.

In 1940 numbers were much higher in a pasture showing no visible damage. In a one-square-yard sample taken in September, there were 13·2

larvae per square foot. Of 119 larvae recorded 18 per cent were in the second, and 82 per cent in the third instar. In another sample a cube of side one foot contained 12 second and four third instar larvae.

Plant Succession following Larval Damage

Grass damaged by severe infestations of *R. magnicornis* died unless a few roots remained and favourable growing weather occurred, as happened in the 1933–34 summer. Often before grass cover was fully restored on a damaged area it was colonized by a number of species of weed.

In an area of damaged pasture observed during the summer of 1936–37 odd pieces of affected paspalum were still alive in March, and there were also a few runners of kikuyu which had been planted. The damaged paspalum was brownish, the dead buffalo whitish-brown.

In December 1937 the area bore the following vegetation: inkweed (*Phytolacca octandra* L.), milk thistle (*Sonchus oleraceus* L.), false dandelion (*Hypochoeris radicata* L.), white clover (*Trifolium repens* L.), paspalum, button weed (*Modiola caroliana* (L.) G. Don.), *Solanum* sp., black currant (*Solanum nigrum* L.), Paddy's lucerne (*Sida rhombifolia* L.), crowfoot grass (*Elusine indica* (L.) Gaertn.), smart weed (*Polygonum aviculare* L.), all of which were self-sown, rye grass (*Lolium ?perenne*), which was carried by cattle, and kikuyu which had been planted.

Nine months later this area was well covered by paspalum, buffalo with some kikuyu and white clover, and several species of weed. There was no trace of dead grass and the plants were well rooted. Tall weeds, e.g., inkweed, Paddy's lucerne, Scotch thistle (*Cirsium vulgare* (Savi) Ten.) indicated the area which had earlier sustained the most severe damage.

In January 1940 more than 25 acres of this farm were either suffering current damage or were covered by regenerating weeds following earlier injury.

In January 1941 the area was light green in colour due to dominance of light coloured kikuyu and Parramatta grass. Odd other plants were present, e.g., clover, paspalum, purple top (*Verbena bonariensis* L.), flax-leaved fleabane (*Erigeron bonariensis* L.) and inkweed. In February 1942 one side of the damaged area merged imperceptibly into the rest of the paddock; on the opposite side of the line of demarcation was very slight. In September 1945 the area was covered by kikuyu and could not be distinguished from the rest of the pasture.

Sometimes recovery was much more rapid, e.g., a damaged area on the roadside in April 1933 had completely recovered by January 1935. No attempt had been made to revegetate the area.

B. Damage to Other Species of Plant

The larvae ate the roots and bored into the base of the stalk of sugar cane, often forming a large hole in the latter. The tips of the leaves sometimes became lighter in colour, rendering damaged patches visible from a distance. Affected cane could be pulled out by hand and was easily blown over. Cane was attacked at Dorroughby and Dunoon, as many as 20–30 larvae being reported under a stool in the former locality. At Teven up to eight larvae were found under a stool of damaged cane.

Arrowroot (*? Maranta arundinacea* L.) at Dunoon was damaged in much the same way as cane.

The larvae attacked pineapples (*Ananas sativus* Schult.) eating off the cord roots or excavating quite large holes into the pseudostem and at the

base of the young suckers (Blake and Walker, 1959), causing wilting and sometimes the death of the plant. Damaged plants tended to lie or spread on the ground, but in some cases root regeneration was observed.

Brimblecombe (1942) investigated the depredations of the insect on seedlings of hoop pine (*Araucaria cunninghamii* D. Don) in the Yarraman district, Queensland, and found that larvae attacked the root which they sometimes ate almost to ground level, thereby causing the death of the young plant.

Smith (1946a) stated that young larvae feed, to some extent, on the smaller roots of living peanut plants and the full-grown larvae feed voraciously on the roots of peanuts and other plants in southern Queensland.

Larvae of this species have been recorded as destroying six acres of seedlings of *Glycine javanica* L., sown with green panic (*Panicum maximum* Jacq. var. *trichoglume* Eyles), by severing the tap roots (Anon, 1965).

Enemies of Rhopaea magnicornis

Several species of birds were observed eating larvae or were seen in patches where larvae were present or exposed. Magpies (*Gymnorhina tibicen* (Lath.)), "crows" (*Corvus* sp.), blue jays or black-faced cuckoo shrikes (*Coracina novaehollandae* (Gmelin)), ibis (*Threskiornis spinicollis* (Jam.)), butcher birds (*Cracticus torquatus* (Lath.)), currawongs (*Strepera graculina* (J. White)), were observed to eat larvae, especially in newly-ploughed paddocks. One farmer watched crows scratch, like hens, in their endeavours to locate larvae; in other cases holes were found in damaged areas where crows had been seen. Pigs have been known to eat larvae and to overturn the soil to a depth of a foot in searching for them.

Green muscardine fungus, *Metarrhizium anisopliae* (Metsch.) Sorok., attacked larvae in most of the areas where damage was inspected; occasionally adults were attacked. Infected larvae became sluggish four or five days before death. About three days after death the white mycelium appeared and increased until finally it covered most of the larva, only the mid-ventral area of segments 9–10 being free of fungus. The mycelium turned green due to the formation of spores and finally the larva collapsed and shrivelled and was by then little more than a mass of green spores. Larvae affected by fungus were found in the field in each of the months when visits were made regularly to Tregeagle, viz., January, May, August and December.

Beauvaria bassiana (Bals.) Vuill. was identified from larvae collected at Tregeagle.

Another fungus, attributed to the doubtful genus "*Spicaria*" was obtained from an adult found at Teven.

The mite *Coleolaelaps rhopaea* Wom. (Womersley, 1956) was described from this beetle. It was found on all stages of the insect, but it was not seen to attack its host at any stage, and third instar larvae were bred to maturity after all mites had been removed.

Unidentified white bodies, more or less spherical, egg-shaped or dumbell-shaped, were found occasionally below the skin of larvae, which did not appear to be inconvenienced.

History of Infestations

Damage by *R. magnicornis* larvae has occurred over a period of many years in the Richmond-Tweed district. Accounts of injury to sugar cane at Chilcotts Grass and to pastures at Goonellabah in 1916 were consistent with the activities of this species.

Tregeagle

Personal observation confirmed that pastures in this area have been affected over a period exceeding 30 years. During the 1932–33 summer several farms were attacked. In 1936 and 1937 and in May 1938 damage was evident. In January 1940 more than half of a 50-acre farm was out of production due to attack by larvae or the occupation of damaged land by regenerating weeds. Injury was again evident in 1941 and 1942, but was negligible until the end of 1947, when regular observations ceased. Damage was again evident in January 1967.

Other Localities

Damage has occurred in a number of areas over the years, e.g., Dorroughby, 1933, sugar cane; Dunoon, March 1933, arrowroot, cow cane, sugar cane and grass; Tuckombil Road near Alstonville, 1932–33, two acres of buffalo grass; Terranora, November 1933, pasture; Clunes, 1938, pasture damage was believed to be caused by this species; Main Arm Road near Mullumbimby, winter 1946, pastures affected, also January 1947 larvae and adults were found with other scarab larvae; Nashua, 1945–47, 1951 and for at least the two succeeding years, pineapple; Ewingsdale, 1949–50 and for at least the two following years, pastures; North Tumbulgum, November 1951, 10 per cent of about 13½ acres of pineapple; Lennox Head, 1960–61, buffalo, broad-leaved carpet grass (*Axonopus* sp.), kikuyu and paspalum grasses; Teven for some years prior to 1961, sugar cane; Bangalow, June 1962, pineapple; Crabbes Creek, July 1963, second and third instar larvae occurred at the base of sugar cane plants.

Summary

Rhopaea magnicornis, a typical melolonthine scarab, was studied in the "Big Scrub" country of the north-eastern corner of New South Wales.

The brown adult varies from 22 to 28 mm. in length. The male may be distinguished from all other species of the genus by the eight large lamellae in the antennal club. Females are distinguished from males by their greater size and much smaller six-segmented antennal club.

Beetles did not feed, and in 1 oz. tins 71 specimens lived for an average of 45 days. Adults emerged from pupae in October and evening flights, apparently correlated with light intensity, were noted in November, December and January. Males flew readily in fine weather, females rarely.

Eggs were found at depths of 4–9 in. in the soil during December and January. The white eggs, after deposition in the soil, varied in length from 2·9 to 5·0 mm. and in width from 2·4 to 3·6 mm., increasing in size with age. Hatching occurred from 18 to 24 days after deposition.

The three instars were readily distinguishable by measurements of the head capsule and body length. First instar head capsules varied from 3·0 to 3·2 mm., lengths from 10 to 20 mm. The time spent as first instar larvae could not be determined, but the period between hatching and the appearance of the second instar larvae ranged from 46 to 62 days.

Head capsules and body lengths of second instar larvae varied, respectively from 4·5 to 5·7 mm. and 33–44 mm. The length of the second instar was not ascertained, but the change to the third instar occurred in October and November and no second instar larvae were found by digging in November and December.

In the third instar head capsules varied from 6·2 to 10·2 mm. and lengths from 32 to 62 mm. The insect appeared to spend at least a year in this instar as third instar larvae were found in the soil every month.